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THE ANTHRACNOSE OF THE MANGO IN FLORIDA.

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INTRODUCTION.

The growing of mangos in Florida is beginning to assume some commercial importance. With the increase in size and value of the crops, the mango blight or anthracnose has forced itself upon the attention of the growers and a demand has arisen for remedial or preventive measures. The writer was assigned to the investigation of this disease and spent the seasons of 1912 and 1913 in Dade and Palm Beach Counties, Fla., studying the trouble in the field and laboratory.

A careful canvass of the situation was made during the last week of January and the first week of February, 1912, and all the trees and groves that could be located between Key Largo, 40 miles south of Miami, and Palm Beach, 70 miles north, were examined. It was found that practically all of the seedling trees had bloomed heavily during the first two weeks in January, but that none had set fruit. Most of the trees carried the dried peduncles of the January bloom at this time, and many of them remained attached to the trees until the middle of March, at which time a second crop of bloom appeared. Several hundred of these peduncles were collected and many of them while still on the trees showed spores of a fungus in abundance. A number of those that did not show spores were placed in a moist chamber and they all developed spores of the same type in from 24 to 48 hours. At the same time a number of leaves showing small, irregular, grayish spots were collected and placed in moist chambers. In from three to four days these leaves produced similar spores in the diseased areas. Later in the season young shoots that showed black spots were collected and placed in moist chambers. These also produced the same type of spores from the diseased spots. In the latter part of June, as the fruits were ripening, a number were collected, the skins of which were blotched and disfigured, and these likewise produced the same type of spores. (Pl. I.) Portions of

this material were examined by Mrs. Flora W. Patterson, Mycologist of the Bureau of Plant Industry, who pronounced the fungus to be *Colletotrichum gloeosporioides* Penz.

Hawaiian-grown mangos which were affected by this fungus were received by Mrs. Patterson in 1904, and from time to time during the past four years Miss Clara Hasse, of the Office of Fruit-Disease Investigations, has received mango flower clusters, leaves, and fruits from Porto Rico and Florida which were affected by this fungus.

The disease has been reported by several writers. Fawcett [1] says that the trouble was recognized in Florida by officers of the State experiment station in 1893. It has been reported from Porto Rico by Collins,[2] Hawaii by Higgins,[3] Cuba by Cardin,[4] and Trinidad by Rorer.[5] Of the aforementioned writers, Higgins and Cardin state that the disease may be controlled by spraying with Bordeaux mixture, but their recommendations are not definite and do not give the times and number of treatments necessary, or the experimental data on which the conclusions are based.

Wester [6] reports that he has had successful results in preventing the blighting of the blossoms by spraying. His work was done in Florida and will be discussed in another part of this paper.

It is the purpose of this paper to report in detail such data as have been gathered during the past two years in regard to the behavior of the disease and its control, together with an analysis and discussion of the main limiting factor of the mango in Florida.

SOURCE OF INFECTION.

Colletotrichum gloeosporioides is probably one of the most widely distributed pathogenic fungi in the Tropics. In Florida it causes the well-known wither-tip of citrus fruits and is pathogenic on at least several other fruits.

Bessey [7] has the following to say in regard to its distribution in Florida:

> We see, therefore, that it is not a fungus confined to one or two hosts in a limited area, with which we have to contend, but one of wide distribution and capable of attacking a great many kinds of plants. I have found apparently the same fungus on over 50 plants at Miami, some of them common weeds. This explains why, when the weather conditions or other circumstances are favorable, the disease springs up everywhere without any very apparent center of infection.

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[1] Fawcett, H. S. Mango. Bloom blight (*Gloeosporium mangiferae*). Florida Agricultural Experiment Station Report, 1906, p. 25. 1907.

[2] Collins, G. N. The mango in Porto Rico. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 28, p. 20, 1903.

[3] Higgins, J. E. The mango in Hawaii. Hawaii Agricultural Experiment Station, Bulletin 12, p. 22, 1906.

[4] Cardin, P. P. Bloom blight of mango in Cuba. The Cuba Review, v. 8, no. 5, p. 28–29, 1910.

[5] Rorer, J. B. Annual Report of the Mycologist, Board of Agriculture, Trinidad, p. 7, 1910.

[6] Wester, P. J. Bordeaux mixture for mangos and avocados. The Florida Agriculturist, v. 34, no. 14, p. 1–2, 1907.

[7] Bessey, E. A. Report on plant diseases. Proceedings, 21st Annual Meeting, Florida State Horticultural Society, p. 97, 1908.

Beneath mango trees the disease can be found on the fallen leaves and, as previously mentioned, the blighted peduncles frequently remain in situ for many weeks. These produce spores when conditions of moisture are suitable, and when a second bloom follows before they have fallen the conditions for infection are ideal. Even after they have fallen to the ground they may continue to be a source of infection for some weeks. The mango branch illustrated in Plate II, figure 1, was photographed on March 4, 1912, and shows a persistent, diseased peduncle of the January bloom, with the young March bloom appearing around it.

It seems likely that the potential possibilities for infection are very great at all times and that all that is needed is a favorable season as regards moisture to produce the disease in abundance.

It is probable that the spores do not retain their viability for a great length of time. Pedicels showing spores of the fungus were collected the last week in February, 1912. They were kept in an envelope in a laboratory drawer until July 10 of that year, when attempts were made to germinate them in drops of water on glass slides. A number of slides were prepared on several successive days, but no germination was obtained. Inasmuch as the fresh spores germinate readily under such conditions, it is to be inferred that these spores were no longer viable. Under tropical conditions, however, fresh supplies of spores are being continually produced throughout the year.

INFECTION EXPERIMENTS.

Infection experiments were planned to determine whether the flower clusters of the mango could be artificially inoculated with this fungus and whether the results of such inoculation would be similar to the natural infection observed. The experiments were limited in size and should, perhaps, be repeated on a larger scale, but taken in connection with the other facts presented, i. e., the constant association of this fungus and this alone, as no other was found on diseased inflorescences, and the observations of Bessey and Rolfs given later, they seem to be sufficient to remove any reasonable doubt as to the cause of the disease in Florida. A seedling tree in the Subtropical Garden at Miami was selected for this work. Fourteen buds which had just begun to swell were covered on February 26, 1912, with manila paper bags, which were then tied securely around the branches. On March 5 the bags were removed from four buds, which were about 2 inches long at that time. One was sprayed with distilled water with an atomizer, and three with distilled water containing spores of the anthracnose fungus. They were all immediately rebagged. The work was done at 10 o'clock a. m. on a calm day, and no shoot was exposed for more than three minutes. The spores for all the infection experiments were obtained from diseased panicles which had

been naturally infected. On March 10 the three panicles sprayed with spores showed minute dark spots. The control was clean. On March 21 the four panicles were removed from the tree. The control was still clean, while those sprayed with spores were conspicuously marked on the peduncles and pedicels. Those showing disease were placed in a moist chamber, and in two days large quantities of anthracnose spores had oozed out from the infected parts. This experiment was repeated on two other occasions without variation, and the same results were obtained.

Bessey [1] conducted inoculation experiments with this same organism and writes as follows:

> Under Prof. Rolfs's direction, before he severed his connection with the Subtropical Laboratory, inoculation experiments were begun, which have been continued, with some interruption, under my direction since I assumed charge of the laboratory. These have demonstrated that this fungus (*Colletotrichum gloeosporioides*) is the same one that causes the blossom blight, leaf spot, and fruit rot of the mango and avocado, the tear staining of the mango, and the leaf spots and fruit rots of various other plants.

SPRAYING EXPERIMENTS IN THE SPRING OF 1912.

It was hoped to determine two points by means of these spraying experiments: (1) Is Bordeaux mixture effective in preventing infection of the flower clusters and fruits, and (2) how frequently and at what times is it necessary to spray to get the best results?

Unfortunately for the success of the work, there are no large groves of mangos in Florida. However, the work was done on as large a scale as was possible, and certain results which will be emphasized in other parts of this paper stand out quite clearly. Bordeaux mixture was the only fungicide used, and it was made according to the 3–5–50 formula in 1912 and the 4–6–50 formula [2] in 1913. The spraying outfit consisted of a 50-gallon barrel sprayer, half-inch hose, and 9-foot bamboo extension rods equipped with double Vermorel nozzles. The spraying was done under a pressure of approximately 75 pounds to the square inch. With one exception, noted later, no spray injury was observed at any time, and this is significant, as just such conditions existed as might be expected to induce it, i. e., the weather was moist and showery during the first three weeks in which the spraying was conducted.

The experiments were carried on at Mr. Flanders's place, about 2 miles north, and Mr. Roop's place, about 3 miles west, of Miami.

THE EXPERIMENT IN THE FLANDERS GROVE.

The mangos on the Flanders place consisted of a double row of the Mulgoba variety, each row containing 31 trees. They were divided

[1] Bessey, E. A. Op. cit.

[2] This shows the proportion of copper sulphate (bluestone), lime, and water used in the mixtures.

into 7 blocks, the sprayed blocks alternating with the unsprayed. Block 1 contained 26 trees and the remainder 6 each. Thus, 4 blocks were sprayed and 3 unsprayed. The spraying schedule is shown in Table I.

TABLE I.—*Spraying schedule followed on the Mulgoba mangos on the Flanders place, Miami, Fla., 1912.*

Block.	Dates of spraying.			
	March.	April.	May.	June.
No. 1	8,11,14,19	4,22	13	3,24
No. 3	8,12,19	4,29	27	24
No. 5	8,13,19	4	6	10
No. 7	8,14,20	4	13	24

It was planned to spray block 1 every third day, block 3 every fourth day, block 5 every fifth day, and block 7 every sixth day beginning when the buds began to swell and continuing until the flowers had opened. The treatment was suspended at that time, March 19, until the fruit had set, and then resumed. Thereafter the spraying was to be continued at intervals of three, four, five, and six weeks, respectively, until about two weeks before the fruit was to be picked. It will be seen by examining the dates that the spraying prior to the setting of fruit was varied slightly in blocks 1, 3, and 5. This was due to rainy weather.

On June 29 the fruits on all the trees were examined and careful notes made of their condition. Those which showed no blemishes were classed as clean, those but slightly marked as slightly diseased, and the remainder as badly diseased. The fruit counts are shown in Table II.

TABLE II.—*Fruit counts of the Mulgoba mangos in the spraying experiment on the Flanders place, Miami, Fla., 1912.*

Block.	Condition of the fruit.		
	Clean.	Slightly diseased.	Badly diseased.
No. 1 (sprayed)	10	1	0
No. 2 (unsprayed)	0	0	1
No. 3 (sprayed)	71	25	9
No. 4 (unsprayed)	0	2	11
No. 5 (sprayed)	7	1	0
No. 6 (unsprayed)	0	0	0
No. 7 (sprayed)	12	0	0

The trees in this experiment bloomed lightly and irregularly, and the total number of fruits harvested from each sprayed block is not sufficient to give any definite conclusions in regard to the relative merits of the various spraying schedules; but the fact that considerably more fruit was carried through to maturity on the sprayed than on the unsprayed trees indicates that the protecting of the panicles from

fungous infection was decidedly beneficial. This must not be taken as showing that spraying made the fruit set better, for such was not the case. The fruit set equally well on the unsprayed trees, but the diseased panicles were not able to carry it to maturity.

Of the 136 sprayed fruits harvested, 74 per cent were bright and clean, 20 per cent slightly diseased, and 6 per cent badly diseased. Only 14 fruits were harvested from the unsprayed trees. Of these, 2, or 14 per cent, were slightly marked by the fungus and 12, or 86 per cent, badly diseased.

THE EXPERIMENT ON THE ROOP FARM.

Two seedling trees were used in the experiment on the Roop farm, both of which bloomed heavily. One was sprayed according to the plan used in block 1 of the Flanders experiment. They had both bloomed in January, and at the time of the beginning of the second bloom a number of diseased peduncles were still on the trees. (Pl. III, figs. 1 and 2.) No fruit was set from this January bloom. The dates of spraying are given in Table III.

TABLE III.—*Spraying schedule followed on the seedling mango on the Roop place, Miami, Fla., 1912.*

	February.	March.	April.	May.	June.
Dates of spraying	29	2, 5, 8, 11, 14	1, 22	13	3

The last spraying, which should have been given on June 24, was omitted because the few fruits which remained on the tree were so badly diseased that it was not thought worth while to spray again. The fruit counts were made on June 29 and were as follows:

TABLE IV.—*Fruit counts of the seedling mangos in the spraying experiment on the Roop place, Miami, Fla., 1912.*

Tree.	Condition of the fruit.		
	Clean.	Slightly diseased.	Badly diseased.
No. 1 (sprayed)	4	13	37
No. 2 (unsprayed)	0	0	1

Only one fruit was set on the unsprayed and only 54 on the sprayed tree. The panicles on the sprayed tree showed no sign of disease up to the time of blooming. Most of the blossoms became infected, however, as they opened. The pedicels showed disease as far back as the flowers extended about a week after blooming. These were covered with Bordeaux mixture practically all of the time, but the disease spots developed beneath the covering of the

fungicide. They did not develop on the peduncles, however, which points very strongly to infection having taken place through the blossoms. The panicles on the unsprayed tree began to show diseased spots on the pedicels and peduncles before their growth in length was more than half complete, and practically all of the blossoms blighted, the one fruit which set being in the extreme top of the tree. Plate IV, figures 1 and 2, shows the typical condition of a blighted panicle as compared with one in full bloom which has not yet developed any sign of the disease.

SPRAYING EXPERIMENTS IN THE WINTER AND SPRING OF 1913.

As during the preceding season, the mangos bloomed quite generally during the winter. The buds began to swell about December 18. Most of the bloom was shed by January 10 and not 1 per cent of this bloom set fruit.

The buds on two large seedling trees on the Roop place were beginning to push out on December 24, and one of these was selected to be sprayed every other day to test the efficacy of spraying to control the blossom-blight form of the disease. It was considered that this would be a thorough test, as the blighting of the blossoms is the normal thing with the winter bloom. Mr. Roop states that these trees have bloomed regularly in the winter for the past six years, but have never set fruit from this bloom. Spraying was begun on December 24 and continued every third day until January 16. At this time the fruit had set, and the spraying was continued every fourth day until February 3. At this time the young fruits had reached a diameter of one-fourth to three-eighths of an inch, and the next two sprayings were applied at 7-day intervals. Two more were applied at approximately 10-day intervals and the last on March 22 after a lapse of 14 days, when the fruit was about half grown. The dates on which spray was applied follow: December 24, 26, 28, 30; January 1, 3, 6, 8, 10, 13, 16, 20, 24, 28; February 3, 10, 17, 26; March 8, 22.

While the tree bloomed profusely, only a fair crop was set. By this is meant that the tree could have carried twice as much fruit without being unduly burdened. The blossoms on fully half of the panicles blighted, and all of those on the unsprayed tree blighted.

This experiment was carried a step farther in March by spraying a portion of a Totafari tree in the Subtropical Garden at Miami every day from March 17 to April 1; that is, while the bloom was pushing out and developing. This was evidently too much spraying, for, while no disease developed, no fruit was set and the young foliage was scorched.

It should also be noted that the fruit on the seedling tree on the Roop place received no spray after it was half grown, but it was clean and free from disease when harvested the middle of May, almost two months after the last spraying.

An experiment was conducted on the spring bloom about 3 miles northwest of Miami, on a place managed by Mr. C. O. Hickok. It included a block of 25 seedling trees which bloomed profusely between March 8 and 28. Spraying was begun when the panicles on most of them were about half grown, March 14. The flowers on six trees were beginning to open when the first spray was applied. No trace of disease was apparent on the inflorescence at that time. Seven trees were left without spray, as controls. The spraying dates were as follows: March 14, 20, 25; April 2.

Sprayed and unsprayed trees alike blighted. An occasional fruit was set, but the total number was negligible and the unsprayed trees had quite as much proportionately as the sprayed.

DISCUSSION OF THE SPRAYING EXPERIMENTS.

Mangos come into bloom very irregularly. On March 8, 1912, on the Flanders place most of the buds were just beginning to swell, but a number had reached a length of 4 or 5 inches. This habit of irregular blooming makes it difficult to select a proper time to begin spraying. Spraying before the buds begin to grow is of no value so far as protecting the inflorescence, and later the young fruit, is concerned. These must be kept covered with the fungicide while growing if fungus invasion is to be prevented. The difficulty of so protecting the inflorescence is at once apparent. Elongations of the panicles continue for a period ranging from 10 to 15 days. Those which were sprayed every third day were practically all disease free when the flowers began to open. This, however, required four sprayings in one case and six in the other. Those sprayed every fourth day showed but little more disease than those sprayed every third day, but those on which the spray was applied at 5 and 6 day intervals had traces of disease, showing that they were less perfectly protected.

The spraying of the inflorescence at least three times, beginning when the buds are just swelling and repeating every fourth day until the flowers open, will help to prevent the dropping of fruit caused by the disease on the peduncles and pedicels.

The blighting of the blossoms is by far the most serious form of this disease, as it does not lend itself to control by spraying. The inflorescence may be kept in a clean condition up to the time of blooming; but, when this takes place, immediately there are hundreds of points which are not covered by the fungicide and are open to infection. Observation has shown that infection takes place in this manner. A Totafari tree in the Subtropical Garden bloomed heavily in March, 1912. It was sprayed three times with Bordeaux mixture between the times when the buds began to swell and the flowers opened. The peduncles and pedicels showed no trace of disease when the flowers began to open. On March 26 the tree was in full bloom and there was every indication that a good crop of fruit would be set.

A SUNDERSHA MANGO TYPICALLY MARKED BY THE ANTHRACNOSE FUNGUS. MIAMI, FLA., JUNE, 1912. PHOTOGRAPHED BY J. M. SHULL.

(Natural size.)

FIG. 1.—THE END OF A MANGO BRANCH SHOWING A PERSISTENT, DISEASED PEDUNCLE OF THE JANUARY BLOOM, WITH A SECOND BLOOM APPEARING AROUND IT. MARCH, 1912.

(Considerably reduced.)

FIG. 2.—A PEDICEL FROM A MANGO PANICLE WHICH BLIGHTED BEFORE THE FLOWERS OPENED. MARCH, 1912.

(Natural size.)

FIG. 3.—YOUNG MULGOBA MANGO FRUITS WHICH SET ON DISEASED PEDICELS. APRIL, 1912.

(Natural size.)

FIG. 1.—A SECTION OF THE TREE SHOWN IN FIGURE 2 OF THIS PLATE, SHOWING THE PERSISTENT, DISEASED PEDUNCLES OF THE JANUARY BLOOM, WITH THE MARCH BLOOM APPEARING AROUND THEM. MARCH 8, 1912. FIG. 2.—A LARGER VIEW OF THE SAME TREE SHOWN IN FIGURE 1, SHOWING THE BLIGHTED CONDITION OF THE SECOND BLOOM 18 DAYS LATER. MARCH 26, 1912.

FIG. 1.—A PORTION OF A SPRAYED MANGO PANICLE WHICH DOES NOT YET SHOW ANY SIGN OF DISEASE. MARCH, 1912. FIG. 2.—AN UNSPRAYED PANICLE ON WHICH THE FLOWERS HAVE BLIGHTED AND FALLEN OFF. MARCH, 1912.

On March 28 all the flowers were dead and dry, and most of them were still adhering to the pedicels. On April 5 the pedicels showed diseased spots as far as the flowers extended. No infection developed on the peduncles. Both the peduncles and pedicels were covered with Bordeaux mixture at this time. The spots on the pedicels developed beneath the mixture, indicating that infection had taken place through the blossoms. A number of these pedicels were placed in a moist chamber, and they all produced spores of the anthracnose fungus in abundance. These observations coincide entirely with those made on the sprayed seedling tree in the Roop experiment in the spring of 1912.

Very little infection occurred in 1913 before the blossoms opened, and this was undoubtedly due to the fact that the weather was quite dry during seven of the first eight days that the bloom was putting out.

Resistant varieties seem to be the only solution of the blossom-blight problem in localities that are subject to rainy weather at blooming time. The Mulgoba mango seems to possess this resistant quality in some degree. A single Mulgoba tree on the Roop farm bloomed at the same time as the seedling trees used in the experiment in the spring of 1912 and received the same spray treatment on the same dates, from the time the buds began to swell until the fruit was harvested. This tree was located most favorably for infection, in the midst of seedling trees which bloomed at the same time, but it set a good crop of fruit and carried it through to maturity. No fruit was set on the seedling trees, with the exception of the one that was sprayed.

On the Boggs farm, south of Miami, was found a collection of Mulgoba and seedling mangos intermixed in the planting. Most of these trees bloomed in March, 1912, and none of them were sprayed. The seedlings set no fruit, while the Mulgoba trees set a fair crop. The disease developed, however, quite seriously on the young fruits a week or ten days after they were formed. The peduncles and pedicels developed the disease also, so that none of the fruit was carried to maturity. Plate II, figure 3, shows the diseased condition of the pedicels after the fruit had set. Plate II, figure 2, shows a pedicel which blighted without setting fruit.

On the Flanders place a similar condition was observed. The flowers on the unsprayed blocks seemed to set fruit quite as well as those on the sprayed blocks, but the unsprayed fruit developed disease a week or ten days after it was formed, and, as the peduncles and pedicels were likewise diseased, practically none of it matured. There is some evidence to show that the Sundersha variety possesses the quality of resistance.

Briefly, then, it seems that the inflorescence can be kept in a disease-free condition by spraying often enough, and that after the

fruit is set it can be brought through to ripening free from fungous infection by spraying at certain intervals, but that spraying is of little or no value in controlling the blossom-blight form of the disease and that profitable sets of fruit can be expected only during seasons which are dry at blooming time, unless varieties which are resistant to the disease are developed and cultivated. Spraying every day prevented a set of fruit and spraying every other day did not save sufficient fruit to justify the expense involved.

There are not sufficient data to make definite and conclusive recommendations as to the frequency with which it will be necessary to spray to get the best results, but it seems probable that the panicles should be sprayed at least every fourth day between the times the buds begin to swell and the flowers begin to open and that after the fruit is set it should be kept covered with Bordeaux mixture during the first 8 to 10 weeks of its development. The fruits are most susceptible to infection just as they are setting. Consequently, it appears that it would be best to make three applications of Bordeaux mixture at weekly intervals, applying the first when about one-half to two-thirds of the blossoms have opened, and following these by a fourth application after a lapse of two weeks and a fifth three weeks later, making five sprayings for the fruit and two, or in some cases three, for the panicles.

INFLUENCE OF THE WEATHER ON POLLINATION.

It has been tentatively suggested by Fawcett[1] and by Collins[1] that the blighting of the blossoms, which is so uniformly observed throughout the Tropics whenever the mango is subject to moist, showery weather at blooming time, may be due to lack of pollination.

It is probable that such conditions interfere with pollination to some extent, but the evidence at hand points strongly to the fact that in Florida, at any rate, the anthracnose fungus is chiefly responsible for this phenomenon. Repeated attempts have been made to germinate the pollen, but without success. The fact that the mango fruits heavily in dry localities indicates that its shy bearing in Florida is due to external conditions rather than to any inherent defect in the plant.

An exact count was made of the number and types of flowers borne on 10 panicles of a Mulgoba, 10 of a Totafari, and 5 of a seedling mango tree. They were made by going over the flower clusters every day and picking off with a pair of forceps the flowers that had opened, the kind and number being recorded. The mango bears two types of flowers, staminate and perfect, and only one stamen is found in each flower.

The 10 Mulgoba panicles bore a total of 7,038 flowers, of which 4,119 were staminate and 2,919 perfect. The 10 Totafari panicles

[1] Op. cit.

bore 9,218 flowers, of which 8,407 were staminate and 811 perfect, and the five seedling panicles bore 2,429 flowers, of which 1,022 were staminate and 1,407 perfect.

The flowers are opening continuously throughout the day and night, and after opening retain their fresh appearance for about two days. The staminate flowers wither and drop off the third or fourth day, while the ovaries of the perfect flowers generally begin to take on a dark-green color on the third day.

A peculiar condition is observed when panicles bearing freshly opened flowers are removed from the tree. Within 15 to 30 minutes the pistil and stamen of each perfect flower curve toward each other and frequently meet, and in some cases wrap themselves together.

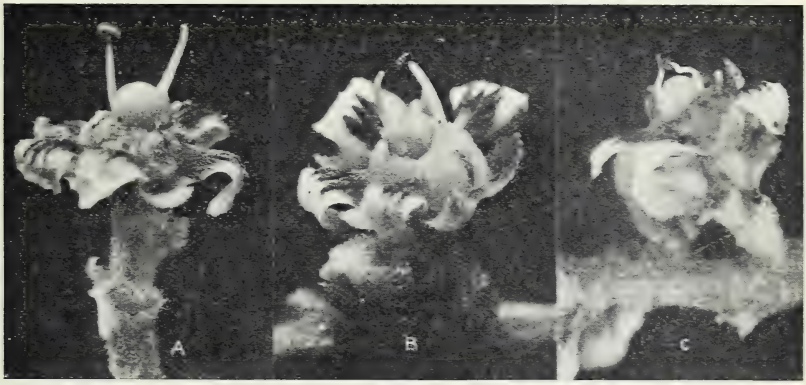

FIG. 1.—Complete mango flowers, much enlarged: *A*, A freshly opened flower; *B* and *C*, flowers which have been removed from the tree for 30 minutes, showing the flexing of the stamen and pistil.

This condition has never been observed on the tree and is not thought to have any bearing on the fertilizing processes of the flower. Figure 1, *A*, shows a freshly opened flower, and figure 1, *B* and *C*, shows the flexing of the stamen and pistil after the flower has been removed from the tree.

RELATIONS OF WEATHER CONDITIONS TO THE DISEASE.

That there is a very definite relation between weather conditions and the productiveness of the mango has been observed by various writers.

Fawcett and Harris,[1] writing of the mango in Jamaica, have the following to say on this point:

> Although the mango grows freely everywhere, it is not a fruitful tree in every district; in the southern plains and the low, dry limestone hills it produces enormous crops year after year, and very often two crops a year, the main crop from May to August, and the second crop later in the year. * * * In humid districts and along the northern coast the tree is not at all fruitful, except in very dry years, and in the wet districts like Castleton it rarely fruits.

[1] Fawcett, William, and Harris, W. The mango. Bulletin, Botanical Department, Jamaica, n. s., v. 8, pt. 11-12, p. 161-177, 1901.

Collins,[1] discussing the mango in Porto Rico, says:

As to climate, it is much more exacting, and the fact that the tree may thrive well in a given locality and yet fail to produce fruit should be kept always in mind. It may be considered as proven that the mango will be prolific only in regions subject to a considerable dry season. On the moist north side of Porto Rico the trees grow luxuriantly, but they are not nearly so prolific nor is the fruit of such good quality as on the dry south side, and in the very dry region about Yauco and at Cabo Rojo the fruit seems at its best. * * * In Guatemala and Mexico the mango was found at its best only in regions where severe dry seasons prevailed. This position is amply supported by reports of the mango in other localities. * * * Rains at the time of flowering seem to be especially injurious.

Higgins [2] has observed the same condition in Hawaii and writes as follows:

In connection with what has just been said, it will be recalled that the early months of 1904 were marked by heavy rainfall and almost continuous cloudy, wet weather, while the corresponding months in 1905 were exceptionally dry. This unquestionably had much to do with the large crop of mangos produced during the season just passed.

Unfortunately, no bloom records for Florida prior to 1912 are available, but the conditions that prevailed during that season as regards weather and the failure to set fruit are quite in accord with the observations just presented. The seedling mangos in the region around Miami bloomed during the first two weeks of January, 1912. By referring to the Monthly Meteorological Summary of the United States Weather Bureau at Miami for this month, it is seen that of the first 15 days 9 were cloudy, 3 partly cloudy, and 3 clear. Further, out of these 15 days rain fell on 10, the precipitation ranging from 0.01 to 0.66 of an inch, the total precipitation being 1.94 inches. As mentioned previously, practically all of the seedling trees bloomed heavily, but none set fruit.

Most of the second crop of bloom developed during the first 20 days of March, and while some fruit was set from this bloom it was exceedingly light as compared with the amount of bloom. The Monthly Meteorological Summary for the first 20 days of this month shows 10 days cloudy, 9 partly cloudy, and 1 clear. Rain fell on 9 of the 20 days, the precipitation varying from a trace to 1.44 inches, with a total precipitation of 3.17 inches.

The situation was quite as bad during the spring of 1913. The blooming period extended from March 7 to 26 and rain fell on 8 of the 19 days. The black areas in figure 2 show the distribution of the days on which rain fell during the blooming periods of 1912 and of 1913.

It is seen from the foregoing that the suitability of any region for the successful production of mangos is inextricably connected with

[1] Collins, G. N. The mango in Porto Rico. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 28, p. 13, 1903.

[2] Op. cit.

the condition of the weather at blooming time. Given clear dry weather, a good crop of fruit may be expected. Given, on the other hand, rainy weather at blooming time and a failure is practically certain. The only way of telling with certainty that a particular region is suitable for the profitable production of mangos is to have a combined crop and weather record over a sufficiently long term of years to give a fair average. The precipitation records alone are somewhat unreliable. However, the main limiting factor in the successful production of this fruit on the southeast coast of Florida is the anthracnose fungus, which is induced by rainy weather, so a study of the precipitation records for this locality, together with such crop records as are available, is of considerable value. Figures 3 and 4 show the number of rainy days during the months of February and March, respectively, for the period for which a record exists, 1898 to 1913, inclusive, and figure 4 also shows a crop curve for the past four years. The lack of fruit in 1911 was due to the fact that the trees were defoliated the preceding fall by a West Indian hurricane and did not bloom. The curve for the years 1910, 1912, and 1913 shows the relation between the precipitation at blooming time and the crop. There are no bloom records prior to 1912, so to some extent this makes the data unreliable. For example, there might be only five days of rain in a certain month, and it might fall at such a time as to cause no damage; or, on the other hand, there might be five consecutive days of rain at the time that the flowers were opening, which would probably be sufficient to cause the loss of the crop. It would seem, however, that such a combination of circumstances might be expected to be a rather rare occurrence and that an opinion as to the suitability of this region might be predicated on such precipitation records as these with a reasonable degree of certainty.

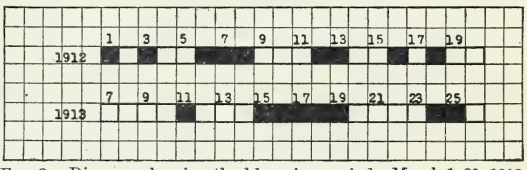

FIG. 2.—Diagram showing the blooming periods, March 1–20, 1912, and March 7–26, 1913. The dark areas show rainy days.

The records for Miami which are given in figures 3 and 4 cover a period of 16 years and show the mean number of rainy days for February to be 2.81 and for March 4.56. The number of seasons below normal for this term of years for February is 8 and for March 11. It is clearly seen here that the seasons of 1912 and 1913 have been decidedly abnormal as regards precipitation.

Wester's [1] experiments, which have been previously referred to, were conducted at Miami during the springs of 1906 and 1907. It will be seen by referring to figures 3 and 4 that these two seasons were comparatively dry, and this undoubtedly accounts for the

[1] Op. cit.

success which he reports with the use of Bordeaux mixture. He fails to present his experimental data, however, and his statements in this and a subsequent publication [1] in regard to this disease are so general that they are of practically no value to the grower.

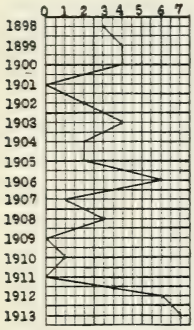

FIG. 3.—Diagram showing the number of days at Miami, Fla., in February, 1898 to 1913, inclusive, with 0.01 inch or more of rainfall. The mean for this period is 2.81 days.

The fact that the mango frequently blooms during the latter part of December and the first part of January has been previously mentioned. It is the rare exception when any fruit is set from this bloom. Aside from rainy weather at the time of blooming, the extremely heavy dews, which are an almost nightly occurrence during the winter months, are, it would seem, largely responsible for this. The dew point is generally reached shortly after sundown, and by 8 o'clock p. m. plants and other outdoor objects are usually dripping with water. With such ideal conditions for infection the uniform blighting of the winter bloom is not to be wondered at.

From a consideration of the data presented, it appears that, while total failures may be expected to occur occasionally, more often the weather conditions will be such as favor good settings of fruit on the spring bloom and that this fruit may be brought through to maturity in a clean and disease-free condition by a moderate number of sprayings with Bordeaux mixture.

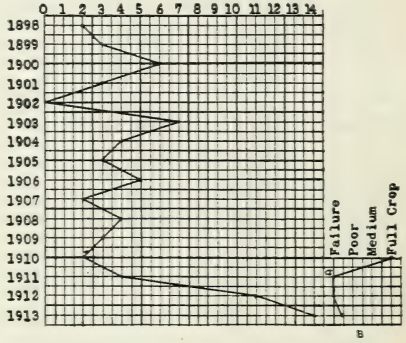

FIG. 4.—*A*, Diagram showing the number of days at Miami, Fla., in March, 1898 to 1913, inclusive, with 0.01 inch or more of rainfall. The mean for this period is 4.56 days. *B*, Crop curve. (a) The failure of 1911 was due to the defoliation of the trees the preceding fall by a West Indian hurricane, the trees not blooming that season.

SUMMARY.

The production of mangos in Florida is seriously interfered with in certain seasons by a fungus which attacks the flower clusters, fruits, leaves, and young shoots.

Infection experiments by the writer and others have shown that *Colletotrichum gloeosporioides* Penz. is the cause of the disease.

The blossom-blight form of the disease is by far the most serious. The amount of damage done by this fungus depends on weather conditions, moist, showery weather being ideal for its ravages.

Spraying with Bordeaux mixture is of little or no value in preventing the blighting of the blossoms during seasons which are rainy at

[1] Wester, P. J. The mango. Philippine Islands, Bureau of Agriculture, Bulletin 18, 60 p., 9 pl., 1911.

blooming time, though spraying has served to keep the panicles and fruits free from infection.

It appears that while total failures may sometimes occur, more often the weather conditions will be such as to favor good settings of fruit.

It is probably never so dry but that spraying will have to be resorted to in order to keep the fruits free from disease after they have set, and no amount of fertilization or soil medication will take its place.

The production of good crops of mangos in Florida and throughout tropical and subtropical zones generally is very definitely related to the weather conditions at blooming time. Large crops can not be expected when the weather at this time is moist and showery. This may be due to some extent to imperfect pollination, but the trouble is chiefly caused in Florida by the anthracnose fungus (*Colletotrichum gloeosporioides*).

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